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is little difference between the importance of the ozone band at $10\ \mu$ and the carbon-dioxide band at $15\ \mu$ except that the former falls at a point in the spectrum where terrestrial radiation is most intense, and where water-vapor has almost no absorption, while the latter falls at a place where the radiation is not so intense and where water-vapor also absorbs powerfully.

No ozone band was found by Fowle in his work with the long tube, but in the solar spectrum it shows strongly. This accords with work of others who show that ozone is found only at high atmospheric levels. Apparently there is not enough ozone in the atmosphere to produce complete absorption in its band at $10\ \mu$, and it may be that the earth's temperature would be profoundly altered if the ozone contents of the air could be changed. If it were possible, for instance, to charge the surface air above citrus fruit orchards strongly with ozone on a frosty night, perhaps hurtful frosts could thereby be warded off.

Carbon-dioxide exists in the atmosphere so plentifully that its full possible influence seems probably to be exerted. No increase of CO_2 would seem likely to produce a considerable effect on terrestrial temperature, and it is probable that the CO_2 content of the air could be reduced to less than a quarter of its present amount without notable temperature effects.

¹ *Smithsonian Misc. Coll.*, Washington, 68, No. 8.

² *Ibid.*, 65, No. 3, p. 54.

MOBILITIES OF IONS IN VAPORS

BY KIA-LOK YEN

RYERSON PHYSICAL LABORATORY, UNIVERSITY OF CHICAGO

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In a former paper on the Mobilities of Ions in Air, Hydrogen, and Nitrogen (these PROCEEDINGS, 4, 1918, 91), the conclusion was reached that the so-called cluster hypothesis could no longer claim any reason for its existence and that the arguments for the small-ion theory should be considered conclusive.

It only remained for the small-ion theory to offer an adequate explanation for the difference between the positive and negative mobilities exhibited by all experimental results. This difference can easily be explained by the cluster hypothesis for if the ions were constituted by satellites of molecules surrounding single charges, the difference between the positive and negative mobilities could be ascribed to the difference between the number of constituent molecules in a positive and that in a negative ion. But with the small-ion theory such an explanation is not possible, since all ions are conceived of as single charged molecules.

In the aforementioned paper, an explanation for this experimental fact

was offered on the basis of the Rutherford nucleus-atom theory. It was shown there that the difference between the two mobilities is due to the difference between the numbers of negative electrons in the two kinds of ions. There exists a greater attractive force between the positive ions and the uncharged molecules than that between the negative ions and the uncharged molecules on account of the fact that negative ions have more electrons than the positive. This results in a smaller mean free path, and hence a smaller mobility, for the positive ions than for the negative.

From this point of view it is evident that an excess of positive over negative mobility is scarcely to be expected in either gases or vapors. Since there has been very little work done on vapors and since some careful measurements of mobilities in them are necessary for the verification of this explanation in particular and of the small-ion theory in general, it was considered desirable to make some careful determinations in vapors, and hence the following work was undertaken.

Method and Procedure.—The method and procedure here employed were the same as those employed in the previous experiment. The only difference between this experiment and the former is that in the present one only low frequency alternating field was employed. This was because the vapors worked with required that pressures be sufficiently low for them to remain in the vaporized state, and at such pressures the high frequency high potential oscillating field proved inapplicable on account of the sparking across the gauze and the collecting plate. However, this difference does not at all effect the results, as the main purpose of employing the high potential field was to find out whether the mobilities would increase abnormally, and—since it had already been proved that they did not—the employment of the high potential field in the present experiment was entirely unnecessary.

Another difference between the present and the previous experiment is that in this one a different ionization chamber was used. This chamber was constructed on precisely the same plan as the former, but covered with a bell jar of about one-sixth the size of that covering the former apparatus. This last arrangement is more convenient in that it allowed the contents of the chamber to be evacuated and refilled with ease, and that the vapors were rendered as free of impurities as possible.

The vapors were produced by the same method as that employed by Wellisch.¹

The measurements were made in the same manner as before, and the results calculated from the same formula.

Results.—The following tables show the results obtained for the various vapors used. It may be seen from these tables that the results for all these vapors at the various pressures are perfectly consistent with the law that the pressure times the mobility is constant, and that the mean values for the positive mobilities are—excepting in the case of C_2H_5I —smaller than those for the negative mobilities. In the case of C_2H_5I the mean

values may be considered the same. Therefore, the results of the present experiment are directly opposed to those obtained by Wellisch in 1909¹ in so far as the ratios of the negative to the positive mobilities are concerned.

In table 10 there is comparison between the results obtained by Wellisch and those obtained by me. It may be of interest to note that in 1912² Wellisch himself reversed his results for C_2H_6O , C_5H_{12} , and SO_2 .

TABLE 1
SULPHUR DIOXIDE (SO_2)

<i>P</i>	<i>U</i> +	<i>U</i> −	<i>K</i> +	<i>K</i> −	<i>R</i>
60	5.327	5.547	0.421	0.437	1.04
70	4.523	4.523	0.416	0.416	1.00
80	4.935	4.035	0.423	0.423	1.00
90	3.329	3.371	0.394	0.399	1.01
105	2.833	2.895	0.398	0.407	1.02
120	2.669	2.561	0.421	0.404	0.96
Mean.....			0.412	0.414	1.00

TABLE 2
ETHYL ALCOHOL (C_2H_6O)

<i>P</i>	<i>U</i> +	<i>U</i> −	<i>K</i> +	<i>K</i> −	<i>R</i>
15	19.728	19.024	0.389	0.378	0.97
20	14.017	14.017	0.369	0.369	1.00
25	11.097	11.097	0.365	0.365	1.00
30	9.513	9.864	0.375	0.388	1.03
40	6.053	7.008	0.319	0.367	1.15
Mean.....			0.363	0.373	1.03

P = pressure in mm. mercury. *U* + = Positive mobility. *U* − = Negative mobility. *K* + = Positive mobility reduced to 760 mm. mercury. *K* − = Negative mobility reduced to 760 mm. mercury. *R* = *K* − / *K* +.

TABLE 3
ALDEHYDE (C_2H_4O)

<i>P</i>	<i>U</i> +	<i>U</i> −	<i>K</i> +	<i>K</i> −	<i>R</i>
30	7.885	8.560	0.311	0.338	1.09
34		7.885		0.352	
38	5.993		0.300		
43	5.256	5.548	0.297	0.313	1.07
45	5.166	5.350	0.306	0.317	1.05
50	4.832	5.078	0.318	0.334	1.05
55	4.280	4.610	0.310	0.333	1.07
Mean.....			0.307	0.331	1.07

TABLE 4
PENTANE (C_5H_{12})

<i>P</i>	<i>U</i> +	<i>U</i> −	<i>K</i> +	<i>K</i> −	<i>R</i>
30	8.812	12.483	0.347	0.493	1.42
40	7.491	8.812	0.394	0.462	1.18
50	5.993	6.968	0.397	0.445	1.12
50	5.993	6.968	0.397	0.445	1.12
60	4.832	5.448	0.382	0.430	1.12
66	4.540	4.994	0.394	0.434	1.10
Mean.....			0.385	0.451	1.17

TABLE 5
ETHYL CHLORIDE (C_2H_5Cl)

<i>P</i>	<i>U</i> +	<i>U</i> −	<i>K</i> +	<i>K</i> −	<i>R</i>
30	7.683	7.885	0.303	0.311	1.02
40	5.762	5.993	0.303	0.317	1.05
40	5.549	5.762	0.292	0.303	1.04
50	4.756	5.078	0.313	0.334	1.07
50	4.681	4.833	0.308	0.318	1.03
Mean.....			0.304	0.317	1.04

TABLE 6
ACETONE (C_3H_6O)

<i>P</i>	<i>U</i> +	<i>U</i> −	<i>K</i> +	<i>K</i> −	<i>R</i>
50	3.699	4.035	0.243	0.265	1.09
60	2.959	3.131	0.235	0.247	1.05
64	2.833	2.959	0.239	0.250	1.07
70	2.513	2.665	0.229	0.245	1.07
76	2.336	2.421	0.234	0.242	1.03
80	2.219	2.296	0.234	0.242	1.03
Mean.....			0.236	0.247	1.04

TABLE 7
ETHYL ACETATE ($C_4H_8O_2$)

<i>P</i>	<i>U</i> +	<i>U</i> −	<i>K</i> +	<i>K</i> −	<i>R</i>
50	3.309	3.648	0.219	0.240	1.09
60	2.567	3.167	0.229	0.250	1.09
65	2.701	2.900	0.231	0.248	1.07
70	2.421	2.663	0.223	0.245	1.09
75	2.290	2.533	0.226	0.250	1.10
80	2.172	2.334	0.230	0.246	1.07
Mean.....			0.226	0.247	1.09

TABLE 8
ETHYL IODIDE (C_2H_5I)

<i>P</i>	<i>U</i> +	<i>U</i> −	<i>K</i> +	<i>K</i> −	<i>R</i>
30	5.166	4.833	0.203	0.191	0.94
35	4.104	4.161	0.189	0.192	1.01
50	2.466	2.512	0.162	0.169	1.04
60	2.336	2.296	0.184	0.181	0.98
60	2.141	2.166	0.169	0.171	1.01
Mean.....			0.181	0.181	1.00

TABLE 10
COMPARISON

<i>P</i>	<i>U</i> +	<i>U</i> −	<i>K</i> +	<i>K</i> −	<i>R</i>	VAPOR	WELLISCH				K.-L. YEN	
							1909 ¹		1915 ²		1917	
							<i>K</i> +	<i>K</i> −	<i>K</i> +	<i>K</i> −	<i>K</i> +	<i>K</i> −
						C_2H_4O	0.31	0.30			0.307	0.331
						C_2H_6O	0.34	0.27	0.39	0.412	0.363	0.373
						C_3H_8O	0.31	0.29			0.236	0.247
						SO_2	0.44	0.41	0.415	0.414	0.412	0.414
						C_2H_5Cl	0.33	0.31			0.304	0.317
						C_5H_{12}	0.36	0.35	0.370	0.440	0.385	0.451
						$C_4H_8O_2$	0.31	0.28			0.226	0.247
						C_2H_5I	0.17	0.16			0.181	0.181
						CH_3I	0.21	0.22	0.24	0.233	0.216	0.226
Mean							0.216	0.226			1.05	

Conclusion.—From the results of the present experiment, it is evident that the apparent difficulty with the explanation proposed for the difference between the positive and negative mobilities does not really exist at all. It only remains for the exponents of the small-ion theory to deduce an exact formula for the mobility of ions on the basis of the Rutherford-Bohr theory from which we should expect that the peripheral negative electrons in the molecules and the ions would play the dominant if not indeed the only rôle in collisions.

I wish it to go on record that the present experiment was undertaken at the suggestion of Prof. R. A. Millikan, and under his direction; and also to thank Mr. W. R. Westhafer for his assistance in taking some of the measurements and computing some of the results.

¹ *Phil. Trans. R. Soc., London*, (A), **209**, 1909, (249).

² *Phil. Mag., London*, **34**, 1917, (59).